

## In the United States Patent and Trademark Office

Appn. Number: \_\_\_\_\_  
Appn. Filed: \_\_\_\_\_  
Applicant(s): WOOLLAM ET AL.  
Appn. Title: SPECTROSCOPIC ELLIPSOMETER AND POLARIMETER SYSTEMS  
Examiner/GAU: \_\_\_\_\_ /324

Mailed: WITH APPLICATION

At: \_\_\_\_\_

### Information Disclosure Statement

Commissioner of Patents and Trademarks  
Washington, District of Columbia 20231

Sir:

Attached is a completed Form PTO-1449 and copies of the pertinent parts of the references cited thereon.

Following are comments on these references pursuant to Rule 98:

#### PATENTS

Patents to Johs et al., Serial No. 5,872,630<sup>✓</sup> and 6,353,477<sup>✓</sup>, from which the present Application is derived as a CIP via intervening CIP Applications, is disclosed as it teaches a rotating compensator ellipsometer system.

Patent to Johs, from which the 630 Patent was Continued-in Part, is No. 5,666,201<sup>✓</sup>, filed 09/20/95. The focus in said 201 Patent comprises a detector arrangement in which multiple orders of a dispersed beam of electromagnetic radiation are intercepted by multiple detector systems. Claim 8 in the 201 Patent, in combination with a viewing the Drawings therein, provide conception of the Spectroscopic Rotating Compensator Ellipsometer, as Claimed in Claim 1 of the JAW 630 Patent

Patent No. 5,706,212<sup>✓</sup>, Issued 01/06/98, and Filed 03/20/96 for an Infrared Ellipsometer System Regression based Calibration Procedure. Said 212 Patent describes use of an Substantially Achromatic Rotating Compensator and application of Mathematical Regression in a Calibration procedure which evaluates calibration parameters in both rotating and stationary components. It is not d that the 212 Patent Application was filed four months prior to the earliest priority Patent Application, of Aspnes et al. Patents, (ie. Nos. 6,320,657 B1, 6,134,012, 5,973,787 and 5,877,859), the later of which was Filed n 7/24/96.

Relevant Patents to Aspen et al. are

Nos. 6,320,657;  
6,134,012;  
5,973,787 and  
5,877,859.

These Patents describe a Broadband Spectroscopic Rotating Compensator Ellipsometer System wherein the Utility is found in the use of a "substantially Non-Achromatic" compensator, (see Claim 1 in the 657 Patent), and selecting a Wavelength Range and Compensator so that "an effective phase retardation value is induced covering at least from 90 degrees to 180 degrees", (012 Patent), over a range of wavelengths of at least 200 - 800 nm. The 787 and 859 recite that at least one wavelength in said wavelength Range has a retardation imposed of between 135 and 225 Degrees, and another wavelength in the wavelength Range has a retardation imposed which is outside that retardation Range.

Published PCT Application is No. WO 01/90687 A2, which is based on US Application Serial No. 09/575,295 filed 05/03/01. This Application was filed by Thermawave Inc. and specifically describes separate use of a  $2\omega$  and a  $4\omega$  term to provide insight to sample thickness and temperature.

Patent, No. 4,053,232 to Dill et al. describes a Rotating-Compensator Ellipsometer System, which operates utilizes monochromatic light.

Two Patents to Rosencwaig et al. and Redner, respectively, which identify systems which utilize Polychromatic light in investigation of material systems are:

Nos. 5,596,406; and  
4,668,086

were also identified.

Also identified is a Patent to Woollam et al, No. 5,373,359 as it describes a Rotating Analyzer Ellipsometer System which utilizes white light.

Patents continued from the 359 Woollam et al. Patent are:

Nos. 5,504,582 to Johns et al.; and  
5,521,706 to Green et al.

Said 582 Johns et al. and 706 Green et al. Patents describe use of polychromatic light in a Rotating Analyzer Ellipsometer System.

Patent to Johs et al., No. 6,034,777 describes application of ellipsometry in an evacuated chamber comprising windows.

Patent to Johs, No. 5,929,995 is disclosed as it describes application of ellipsometry in an evacuated chamber comprising windows.

Patent to Bernoux et al., No. 5,329,357 is identified as it describes the use of optical fibers as input and output means in an ellipsometer system.

Patent to Chen et al., No. 5,581,350 is identified as it describes the application of regression in calibration of ellipsometer systems. This Patent does not cite a prior art paper by Johs cited below.

Additionally, Patents pertaining to optical elements, and particularly to compensators/retarders per se are:

Patent No. 4,917,461 to Goldstein, describes an achromatic infrared retarder comprised of two identical prisms in combination with a reflective surface;

Patent No. 4,772,104 to Buhrer which describes an achromatic optical filter comprised of two birefringent disks;

Patent No. 4,961,634 to Chipman describes an infrared achromatic retarder comprised of CdS and CdSe plates aligned with the fast axes thereof perpendicular to one another;

Patent No. 6,181,421 to Aspnes et al., describes a tipped Berek Plate Compensator.

Patent No. 5,946,098 to Johs, Herzinger and Green, describes numerous optical elements.

In addition Patents to Johs et al.:

Nos. 6,084,674;  
6,118,537;  
6,100,981;  
6,141,102;

5,963,325;  
6,084,674 and

6,084,675 to Herzinger et al., which Applications depend from Application Serial No. 08/997,311 filed 12/23/97, now said Patent 5,946,098;

Additional Patents cited in prosecution of the foregoing

Compensator related Patents are:

Patent No. 548,495 to Abbe;  
Patent No. 4,556,292 to Mathyssek et al.;  
Patent No. 5,475,525 Tournois et al.;  
Patent No. 5,016,980 Waldron;  
Patent No. 3,817,624 to Martin; and  
Patent No. 2,447,828 to West.

Patents to Robert et al.:

Nos. 4,176,951; and  
4,179,217;

are also disclosed as they describe rotating Birefringent elements in Ellipsometers which produce  $2\omega$  and  $4\omega$  components.

PCT Patent Application, No. WO 01/086257 is also known and is disclosed as it describes a combination of an aperture and lens to define a spot on a sample.

Patent to Lacey et al., No 5,793,480 is disclosed as it describes a field stop and lens combination in an ellipsometer prior to a sample.

Patent to Spanier et al., No. 5,166,752 is disclosed as it describes an ellipsometer with lenses and apertures before and after a sample.

Patent to Lessner et al., No. 4,054,812 describes a Source of Spectroscopic electromagnetic radiation which provides heat sink and ozone containment.

Patent to Ellebracht et al., No. 4,322,165 is disclosed as it describes purging in a VUV Plasma Atomic Emission Spectroscopic Instrument.

Patent to Burns et al., No. 4,875,773 is disclosed as it describes an Optical System for a Multidetector Array Spectrograph.

Patent to Freeouf, No. 6,414,302 is disclosed as it describes a High Photon Energy, (up through 10eV), Range Reflected Light Characterization System.

Patent to Aspnes et al., No. 5,091,320 is disclosed as it describes application of ellipsometry with, but outside an evacuated chamber.

Patent to Hartley, No. 4,770,895 is disclosed as it describes application of ellipsometry with, but outside an evacuated chamber.

Published Patent Application by McAninch, No, 2002/0149774 A1 is disclosed as it describes purging a measurement region near a substrate in a metrology tool.

A J. A. Woollam CO. Flyer titled VUV-VASE (Registered Tradeamrk), is disclosed as it describes a monochromater based rotating analyzer ellipsomete system in a purged chamber.

Patent to Ivarsson, No. 6,493,097 is disclosed as it describes a Detector Array in an analytical instrument using electromagnetic radiation.

Patent to Stewart, No. 5,229,833 is disclosed as it describes an optical sensor comprising a CCD Array.

Patent to Azzam, No. 5,337,146 is disclosed as it describes a spectrophotometer comprising a linear array detector.

Patent to Wilkins et al., No. 6,031,619 describes an imaging spectrometer with a CCD Matrix or Row detector.

Patent to Imai et al., No. 5,818,596 is disclosed as it describes use of purging gas to prevent contaminants on samples, but does not disclose ellipsometry or a multiple detector element detector array.

Published Patent Application by Wang et al., No. 2003/0071996 A1 is disclosed as it involves purging of the environment of one beam in a system involving two beams.

Published Patent Application by Eckert et al., No. US 2003/0150997 A1 is disclosed as it describes use of VUV wavelengths and purging.

#### ARTICLES

An article by Johs, titled "Regression Calibration Method For Rotating Element Ellipsometers", which appeared in Thin Film Solids, Vol. 234 in 1993 is also identified as it predates the Chen et al. Patent and describes an essentially similar approach to ellipsometer calibration.

An Article titled " A New Purged UV Spectroscopic

Ellipsometer to Characterize Thin Films and Multilayers at 157nm", Boher et al., Proc. SPIE, Vol. 3998, (June 2000) is disclosed as it describes a UV Spectroscopic Ellipsometer in combination with Purging.

A presentation titled "Characterisation of Thin Films and Multilayers in the VUV Wavelength Range Using Spectroscopic Ellipsometry and Spectroscopic Photometry", Boher et al., 157nm Symposium, May 2000) is disclosed as it describes a UV Spectroscopic Ellipsometer.

A paper titled "Progress in Spectroscopic Ellipsometry: Applications from Ultraviolet to Infrared", Hilfiker et al., J. Vac. Sci. Technol. A, (Jul/Aug 2003).

A paper titled "Atomic Scale Characterization of Semiconductors by In-Situ Real Time Spectroscopic Ellipsometry", Boher et al., Thin Solid Films 318 (1998) is disclosed as it mentions multichannel detectors.

A paper titled "Optical Characterization in the Vacuum Ultraviolet with Variable Angle Spectroscopic Ellipsometry: 157nm and below", Hilfiker et al., Proc. SPIE Vol. 3998 (2000) is disclosed as it describes use of the J.A. Woollam CO. VUV-VASE which is a monochromator based purged system.

A paper titled "Feasibility and Applicability of Integrated Metrology Using Spectroscopic Ellipsometry in a Cluster Tool", Boher et al., SPIE Vol. 4449, (2001) is disclosed as it describes a multichannelellipsometer applied outside an environmental chamber. This application required electromagnetic radiation to pass through windows to reach a sample.

Four papers authored or co-authored by Collins, which

describe use of multichannels and rotating element ellipsometers, including rotating compensator, but not in an environmental chamber are:

"Characterization of Wide Bandgap Thin Film Growth Using UV-Extended Real Time Spectroscopic Ellipsometry Applications to Cubic Boron Nitride", Zapien et al., J. of Wide Bandgap Materials, Vol 9, No. 3 (Jan 2002);

"Automated Rotating Element Ellipsometers: Calibration, Operation, and Real-Time Applications", Collins, Rev. Sci. Instrum. 61 (8) (aug. 1990);

"Waveform Analysis With Optical Multichannel Detectors: Applications for Rapid-Scan Spectroscopic Ellipsometers", An et al., Rev. Sci. Instrum. 62(8), (Aug. 1991); and

"Multichannel Ellipsometer for Real Time Spectroscopy of Thin Film Deposition for 1.5 to 6.5 eV", Zapien et al., Rev. Sci. Instrum. Vol. 71, No. 9, (Sept. 1991).

A book by Azzam and Bashara titled "Ellipsometry and Polarized light" North-Holland, 1977 is disclosed and incorporated herein by reference for general theory, (not included).

As well, identified for authority regarding regression, is a book titled Numerical Recipes in "C", 1988, Cambridge University Press, (not included).

SINCERELY,

  
JAMES D. WELCH

REG. NO 31,216



Form PTO-1449 REV. 7-98	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO.	SERIAL NO.
<b>LIST OF PRIOR ART CITED BY APPLICANT</b> (Use several sheets if necessary)		APPLICANT <u>Woolan et al</u>	
		FILING DATE _____ GROUP _____	

**U.S. PATENT DOCUMENTS**

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
AA	5872630	2/1999	Tehr et al.	356	369	
AB	5666201	9/1997	Tehr et al.	356	369	
AC	5706212	1/1998	Thompson et al.	356	369	
AD	6320657	11/2001	Aspner et al.	356	369	
AE	6134012	10/2000	Aspner et al.	356	369	
AF	5973787	10/1999	Aspner et al.	356	369	
AG	5877859	3/1999	Aspner et al.	356	364	
AH	4053232	10/1997	Dill et al.	356	118	
AI	5596406	1/1997	Rosenchans et al.	356	327	
AJ	4668086	5/1987	Redner	356	33	
AK	5373359	12/1994	Woolan et al.	356	328	

**FOREIGN PATENT DOCUMENTS**

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	N
AL							
AM							

**OTHER PRIOR ART (Including Author, Title, Date, Pertinent Pages, Etc.)**

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	OTHER PRIOR ART (Including Author, Title, Date, Pertinent Pages, Etc.)
AR	WD 01/90687	A2	by Therman wave
AS			

EXAMINER	DATE CONSIDERED
----------	-----------------

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Form PT-1449  
Rev. 7-80

U.S. DEPARTMENT OF COMMERCE  
PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO.	SERIAL NO.
APPLICANT <i>Woolham et al.</i>	
FILING DATE	GROUP

LIST OF PRIOR ART CITED BY APPLICANT  
(Us several sh o/s il necessary)

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPR PRIATE
	AA	5504582	4/1996	Johr et al	356	369	
	AB	5521706	5/1996	Green et al.	356	369	
	AC	6034777	3/2000	Johr et al.	356	369	
	AD	5929995	7/1999	Johr	356	369	
	AE	5329357	7/1994	Bernoux et al.	356	369	
	AF	5581350	12/1996	Chen et al	356	369	
	AG	4917461	4/1990	Goldstein	350	286	
	AH	4772104	9/1988	Buhrer	350	403	
	AI	4961634	10/1990	Chipman et al.	350	403	
	AJ	6181421	1/2001	Alper et al.	356	369	
	AK	5946098	8/1999	Johr et al.	356	364	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
							YES	NO
	AL							
	AM							

OTHER PRIOR ART (Including Author, Title, Date, Pertinent Pages, Etc.)

AR	
AS	

EXAMINER	DATE CONSIDERED
----------	-----------------

\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Form PT-1449  
REV. 7-80M

U.S. DEPARTMENT OF COMMERCE  
PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO.

SERIAL NO.

**LIST OF PRIOR ART CITED BY APPLICANT**  
(Us several sh als if nec ssary)

APPLICANT

Woollan et al.

FILING DATE

GROUP

**U.S. PATENT DOCUMENTS**

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
AA	6 0 8 4 6 7 4	7/2000	Johr et al.	358	364	
AB	6 0 8 4 6 7 5	7/2000	Hertzinger et al.	358	369	
AC	6 1 1 8 5 3 7	9/2000	Johr et al.	358	369	
AD	6 1 0 0 9 8 1	8/2000	Johr et al.	358	364	
AE	6 1 4 1 1 0 2	10/2000	Johr et al.	358	364	
AF	5 9 6 3 3 2 5	10/1999	Johr et al.	358	364	
AG	5 9 4 6 0 9 8	8/1999	Johr et al.	358	364	
AH	5 8 4 4 9 5	10/1895	ABDE			
AI	4 5 5 6 2 7 2	12/1985	McThysse et al.	350	394	
AJ	5 4 7 5 5 2 5	12/1995	Ternar et al.	359	245	
AK	3 8 1 7 6 2 4	6/1974	Martin			

**FOREIGN PATENT DOCUMENTS**

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
AL							
AM							

**OTHER PRIOR ART (Including Author, Title, Date, Pertinent Pages, Etc.)**

AR							
AS							

EXAMINER

DATE CONSIDERED

\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Form PT-1449  
REV. 7-90

U.S. DEPARTMENT OF COMMERCE  
PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO.

SERIAL NO.

LIST OF PRIOR ART CITED BY APPLICANT  
(Use several sheets if necessary)

APPLICANT

William et al

FILING DATE

GROUP

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	AA	2447828	2/1945	West			
	AB	4176951	12/1979	Robert et al.	356	33	
	AC	4179217	12/1979	Robert et al.	356	33	
	AD	5793480	8/1998	Lacey et al	356	73	
	AE	5166752	11/1992	Spanier et al.	356	369	
	AF	4054812	10/1977	Lerner et al.	313	44	
	AG	4322165	3/1982	Ellenbracht et al.	356	316	
	AH	4875773	10/1989	Burns et al.	356	328	
	AI	6414302	7/2002	Freehoff	250	225	
	AJ	5091320	2/1992	Aspner et al	437	8	
	AK	4770895	9/1988	Hartley	427	10	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
							YES	NO
	AL							
	AM							

OTHER PRIOR ART (Including Author, Title, Date, Pertinent Pages, Etc.)

	1	WO 01/086257A3	Sentech Instrument
	2	US2002/0149774A1	Mc Aninch
	3	UUV-VASE, JAWOOLAN	Marketing Flyer

EXAMINER

DATE CONSIDERED

\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Form PTO-1449  
REV. 7-99

U.S. DEPARTMENT OF COMMERCE  
PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO.

SERIAL NO.

**LIST OF PRIOR ART CITED BY APPLICANT**  
(Use several sheets if necessary)

APPLICANT

Woolman et al

FILING DATE

GROUP

**U.S. PATENT DOCUMENTS**

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
AA	6 493 097	12/2000	Ivanov	356	630	
AB	5 229 833	7/1993	Stewart	356	364	
AC	5 337 146	8/1994	Azzam	356	367	
AD	6 031 619	2/2000	Wilkins et al	356	419	
AE	5 818 596	10/1998	Imai et al.	356	381	
AF						
AG						
AH						
AI						
AJ						
AK						

**FOREIGN PATENT DOCUMENTS**

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
AL							
AM							

**OTHER PRIOR ART (Including Author, Title, Date, Pertinent Pages, Etc.)**

	APP	1	US 2003/0071996 A1	Wang et al	4/2003
		2	US 2003/0150997 A1	Ehert et al	8/2003
	AS				

EXAMINER

DATE CONSIDERED

\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

PLEASE USE THIS FOR PTO FORM 1449 REGARDING SCIENTIFIC ARTICLES

Regression Calibration Method For Rotating Element Ellipsometers", which appeared in Thin Film Solids, Vol. 234 in 1993.

"A New Purged UV Spectroscopic Ellipsometer to Characterize Thin Films and Multilayers at 157nm", Boher et al., Proc. SPIE, Vol. 3998, (June 2000).

"Characterisation of Thin Films and Multilayers in the VUV Wavelength Range Using Spectroscopic Ellipsometry and Spectroscopic Photometry", Boher et al., 157nm Symposium, May 2000).

"Progress in Spectroscopic Ellipsometry: Applications from Ultraviolet to Infrared", Hilfiker et al., J. Vac. Sci. Technol. A, (Jul/Aug 2003).

"Atomic Scale Characterization of Semiconductors by In-Situ Real Time Spectroscopic Ellipsometry", Boher et al., Thin Solid Films 318 (1998).

"Optical Characterization in the Vacuum Ultraviolet with Variable Angle Spectroscopic Ellipsometry: 157nm and below", Hilfiker et al., Proc. SPIE Vol. 3998 (2000).

"Feasibility and Applicability of Integrated Metrology Using Spectroscopic Ellipsometry in a Cluster Tool", Boher et al., SPIE Vol. 4449, (2001).

Four papers authored or co-authored by Collins, which describe use of multichannels and rotating element ellipsometers, including rotating compensator, but not in an environmental chamber are:

"Characterization of Wide Bandgap Thin Film Growth Using UV-Extended Real Time Spectroscopic Ellipsometry Applications to Cubic Boron Nitride", Zapfen et al., J. of Wide Bandgap Materials, Vol 9, No. 3 (Jan 2002);

"Automated Rotating Element Ellipsometers: Calibration, Operation, and Real-Time Applications", Collins, Rev. Sci. Instrum. 61 (8) (aug. 1990);

"Waveform Analysis With Optical Multichannel Detectors: Applications for Rapid-Scan Spectroscopic Ellipsometers", An et al., Rev. Sci. Instrum. 62(8), (Aug. 1991); and

"Multichannel Ellipsometer for Real Time Spectroscopy of Thin Film Deposition for 1.5 to 6.5 eV", Zapfen et al., Rev. Sci. Instrum. Vol. 71, No. 9, (Sept. 1991).